Analyzing the effect of an arch support functional insole on walking and jogging in young, healthy females

Zhao, Xiaoxue; Wang, Meizi ; Fekete, Gusztáv; Baker, Julien; Wiltshire, Huw; Gu, Yaodong

Published in:
Technology and Health Care

DOI:
10.3233/THC-181373

E-pub ahead of print: 12/11/2018

Document Version
Peer reviewed version

Analyzing the effect of an arch support functional insole on walking and jogging in young, healthy females

Xiaoxue Zhao[a], Meizi Wang[a], Gusztáv Fekete[b], Julien S Baker[c], Huw Wiltshire[d], Yaodong Gu[a*]

[a] Faculty of Sports Science, Ningbo University, China

[b]Savaria Institute of Technology, Eötvös Loránd University, Szombathely, Hungary.

[c] School of Health and Life Sciences, University of the West of Scotland, UK

d Cardiff School of Sport & Health Sciences, Cardiff Metropolitan University, UK

*Corresponding Author: Yaodong Gu

E-mail Address: guyaodong@hotmail.com

Address: Faculty of Sports Science, Ningbo University, No. 818, Fenghua Road, Jiangbei District, Ningbo, Zhejiang Province, China.

Analyzing the effect of an arch support functional insole on walking and jogging in young, healthy females

Abstract.

BACKGROUND AND OBJECTIVE: The aim of this study was to explore the effectiveness of arch support functional insoles to prevent metatarsalgia.

METHOD: 25 healthy females participated in the study. A Vicon motion capture system was used to collect kinematics data of the lower limb. A AMTI force plate was used to record the vertical ground reaction force (GRF), and the Novel Pedar - X System was used to measure foot pressure while subjects wore normal insoles or functional insoles with an arch support during walking and jogging.

RESULTS: With the arch support functional insoles, the first metatarsal (FM) region's contact area was increased and the peak pressure and time-pressure integral of the FM and second and third metatarsal (SATM) areas were decreased. This suggests less risk of longitude stress injuries of these areas. The ankle dorsiflexion angle of jogging with the 'arch support functional insoles' (RF) and walking with the 'arch support functional insoles' (WF) were significantly increased at initial contact and the knee and hip flexion angle of RF and WF were reduced. The peak hip extension angle of WF and RF also declined. The vertical loading rate of RF was lower, which would be beneficial in reducing the risk of lower limb injuries during jogging.

CONCLUSIONS: The results demonstrate that arch support functional insoles can be used effectively to prevent and decrease pain and promote a suitable weight-bearing pattern in the foot for promoting the health of young females.

Keywords: arch support, insoles, gait, biomechanics

1. Introduction

Metatarsalgia is a frequent complaint in the general population [1]. Metatarsalgia is related to acquired foot deformities which include hallux valgus, in the metatarsophalangeal joints, rheumatoid arthritis and the associated disruption of the plantar fat pad [2]. These common forefoot deformities predominantly affect the female population especially the older females [3]. Therefore, it is necessary and desirable to prevent metatarsal pain in these young women. In addition, the most common site for foot pain in young women is the metatarsal heads (25.0%) has been recorded which is secondary to the heel [4]. A fundamental etiological component of metatarsal pain is the repetitive load observed in the forefoot, and the most common cause was due to the increased load of one or more metatarsal heads during the stance phase of gait [5]. Metatarsal pain is often defined as one or two metatarsal pain regions under the forefoot [2]. The pain extensively amplifies during walking and jogging which is negative to exercise and has been associated with a reduced quality of life [6]. The benefits of surgical treatment for metatarsal pain has been disputed due to the high risk and multiple procedures involved [7]. For less severe and lighter symptoms with no obvious pain in the callosity and associated bone secondary deformity, it has been suggested to use conservative treatments such as fitted insoles.

Metatarsal pads are commonly used as conservative treatments of metatarsalgia which could lead to a redistribution of pressure under the foot to considerably decrease the peak pressure of metatarsal head region. This process could be useful in the non-operative management of metatarsalgia [8,9]. Kang et al., pointed out that expanding the metatarsal pads to cover a larger area by elevating the possibly fallen horizontal arch of the forefoot could diminish plantar pressure under the painful metatarsal heads [3]. In clinical practice, medial arch support is often prescribed by the podiatrist to manage the pronated foot, and beneficial changes in ankle kinematics [10] and foot pain [11] have been observed. The arch support insole adds an arch support to redistribute the foot pressure. Although the use of support material is low-cost, it is difficult to keep the support under the foot in the correct position as slippage has been noted when the foot moves. Therefore, the insole used in this study was fixed to the arch support on the insoles to ensure that they were in the correct position.

Brodtkorb et al., noted that due to the structure of the foot, that included having a rigid lever effect and the special interconnections between the metatarsal and plantar fasciitis, adding a support to the foot may influence more areas [12]. The foot is a multi-joint system, and the adding of the arch may also affect the movement of the other lower limb joints. The aim of this study therefore was to explore the effect of arch support insoles on gait during walking and jogging by analyzing plantar pressure, vertical ground reaction force (GRF) and kinematics data of the lower limb. We hypothesized that the insoles, by adding an arch support might increase the contact area of the feet and insoles, and enhance the attenuation effect of arch. This would increase the loading-share area and as a result, would reduce the load of forefoot to ease and prevent metatarsal pain. A further aim of the study was to explore if the kinematic data of lower limb would also be influenced.

2. Methods

2.1. Participants

Twenty five healthy females (foot size: 37 European size, age: 23.15±1.68 years, height: 162.00±2.80 cm, weight: 51.58±2.74 kg, with the right leg being dominant) were voluntarily engaged in this study. All participants were healthy and had normal development of the foot without clinical history, pes cavus, flat foot, foot disease and/or motor disorder. All participants' feet were suitable to the insoles for adding the arch support. The arch support insole consisted of an insole body and an arch support (figure1). The arch support was mainly inserted at the first two thirds of the black area as outlined in the figure provided. When compared to the outside material of insole, the foot arch area consisted of stiff material to provide a more supportive role helping the function of the arch part of the foot. Prior to the study, for a period of 48 hours, the participants were instructed not to engage in any strenuous exercise. All participants volunteered to take part in the study, written informed consent was obtained, and the study was approved by the Human Ethic Committee of Ningbo University (Number: RAGH20170615).

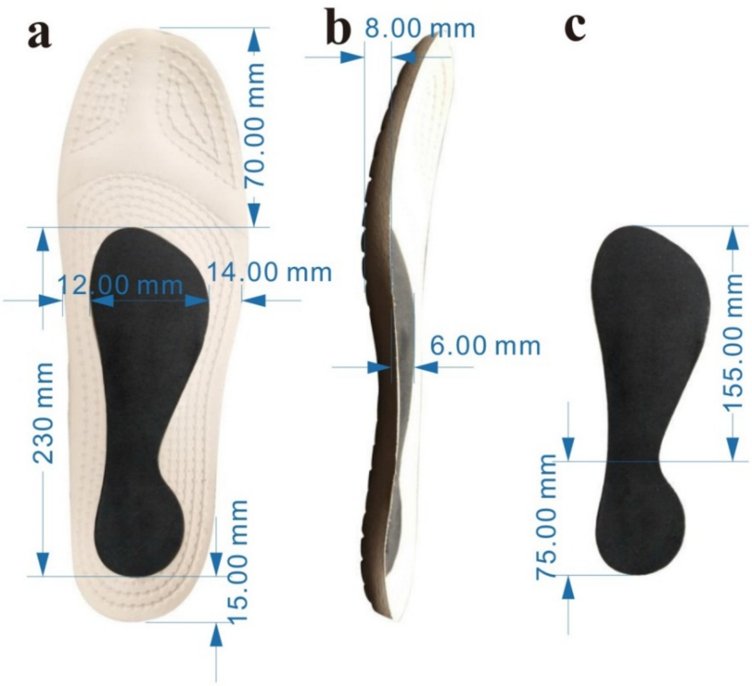

Figure 1 The functional insoles with an arch support (right) in this study. Figure 1-a represents the picture of arch support functional insoles from the front plane view. Figure 1-b shows the photo of the arch support functional insoles from the lateral plane view. Figure1-c exhibits the stiffness arch support material.

2.2. Protocol

The Novel Pedar-X System (Germany) was selected in this study to collect the plantar pressure of the right lower limb. The system's data collection frequency was set at 100Hz to acquire the data while wearing normal insoles, and when wearing arch support functional insoles during walking and jogging. In addition, an eight camera Vicon three dimensional infrared motion capture system (Oxford Metrics Ltd., Oxford, UK) with the frequency of 200Hz was used to collect the kinematics data of lower limb. The AMTI force plate (Advanced Mechanical Technology Inc., Watertown, USA) set at a frequency of 1000 Hz was used to record the GRF.

All participants were asked to wear the arch support functional insoles and normal insoles to walk and jog for a total of 8 times on a 15m long straight trial. According to the product description, all subject were calibrated for using the sensor in a way that would reduce the error caused by sensor damage. To reduce the impact of speed, subjects were also asked to walk and jog in their most natural way with right foot striking on the force plate. The walking velocity was between 1.3

to 1.5 m/s under WF and WN conditions. The jogging velocity was between 2.1 to 2.4 m/s under WF and WN conditions. According to the function of the insoles and the anatomical structure of the foot, the foot was divided into eight areas: big toe (BT), other toes (OT), the first metatarsal (FM), second and third metatarsals (SATM), fourth and fifth metatarsals (FAFM), middle mid-foot (MMF), lateral mid-foot (LMF) and hind-foot (HF).

2.3. Data analysis

All statistical results of each trail were analyzed using SPSS19.0 (SPSS Inc., Chicago, IL, USA). Paired-sampled T test was used to compare the deviation of the plantar pressure, lower limb kinematics and vertical GRF between jogging with the 'arch support functional insoles' (RF), and jogging with the normal insoles (RN), and between walking with the 'arch support functional insoles' (WF) and walking with the normal insoles (WN). Statistical significance set at 0.05 level.

3. Result

3.1. Plantar pressure

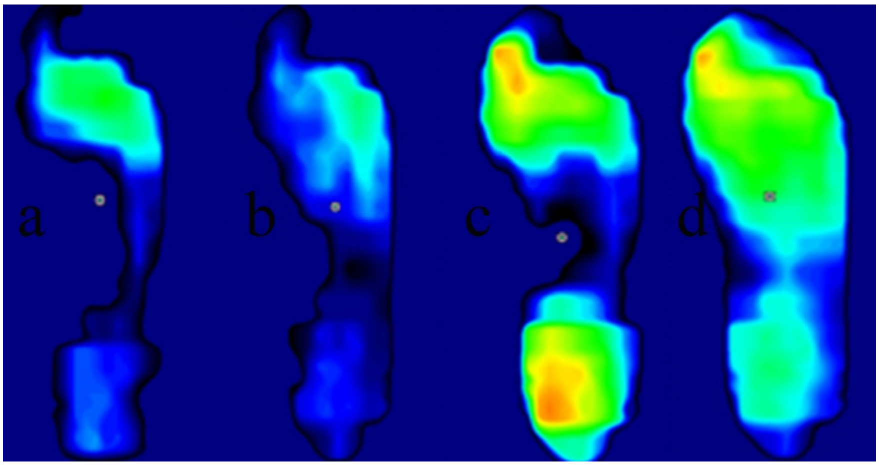

Figure 2 The plantar distribution of the right foot at the maximum contact area during entire support period. Note：Figure 2-a: WN, figure2-b:WF, figure 2-c: RN, figure2-d:RF

Figure 2 shows the plantar distribution of the right foot at the maximum contact area during the entire support period of one participant while performing WN, WF, RN and RF. From figure 2 clear differences of contact area and plantar pressure distribution can be observed. The findings indicate that WF and RF has more contact area and even pressure distribution than WN and RN respectively.

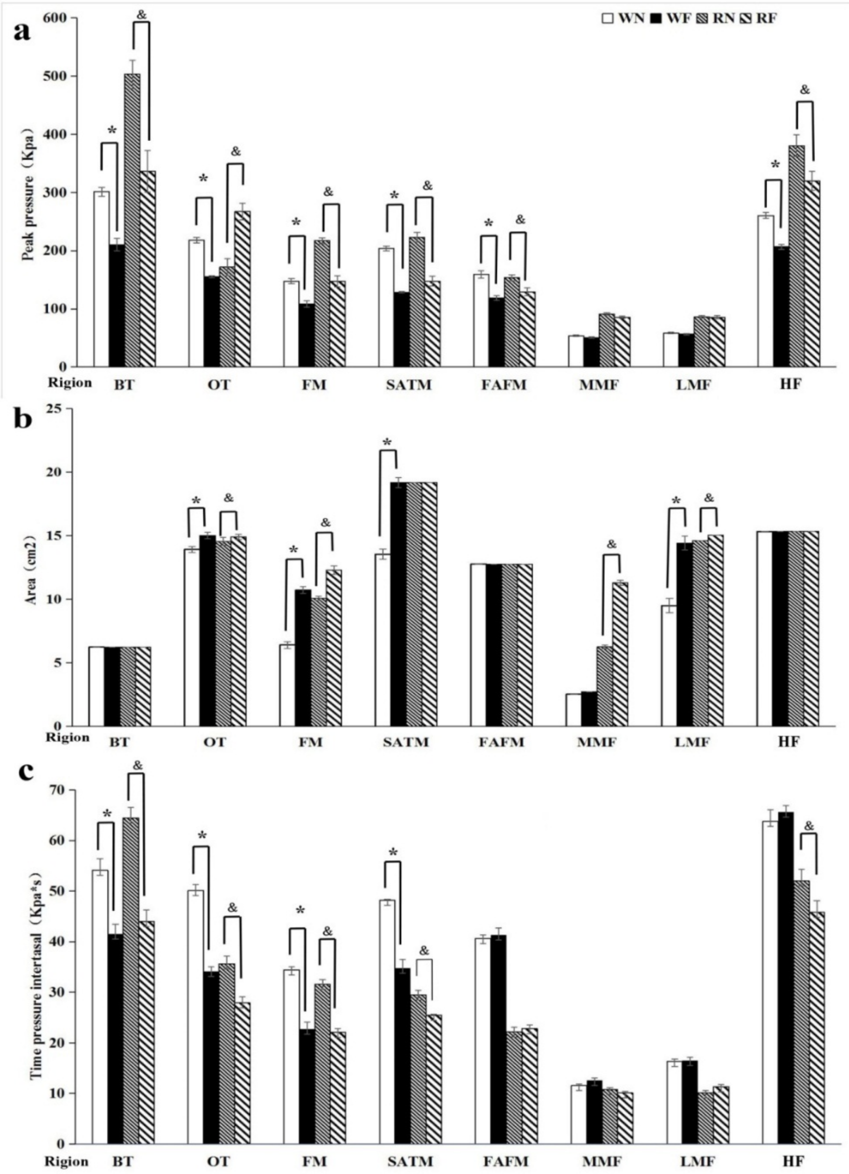

Figure 3 The comparison of different foot area peak pressure, contact area and time-pressure integral.

*Figure 3-a presents the comparison of different foot area's peak pressures. Figure 3- b presents the comparison of different foot area's contact area. Figure 3-c presented the comparison of different foot area's pressure-time integral &represents a significant difference between RF and RN P<0.05, and * represents significant difference between WF and WN P<0.05.*

During walking, the peak pressures of BT, OT, FM, SATM, FAFM and HF were significantly lower under WF condition compared to WN（figure 3-a). The contact areas of OT, FM, SATM and LMF were also larger, with the other region showing no significant deviation under the WF condition in comparison with WN (figure 3-b). The time-pressure integral of BT, OT, FM and SATM under the WF condition indicated lower values and no significant difference found in the other area compared to WN (figure 3-c).

During jogging, the peak pressure of BT, FM, SATM, FAFM and HF under RF condition were lower than RN but the peak pressure of OT was larger（figure 3-a). The contact areas of OT, FM, MMF and LMF under RF condition were larger than RN（figure 3-b). The time-pressure integrals of BT, OT, FM, SATM and RF under RF condition were larger than RN（figure 3-c).

3.2. Kinematics

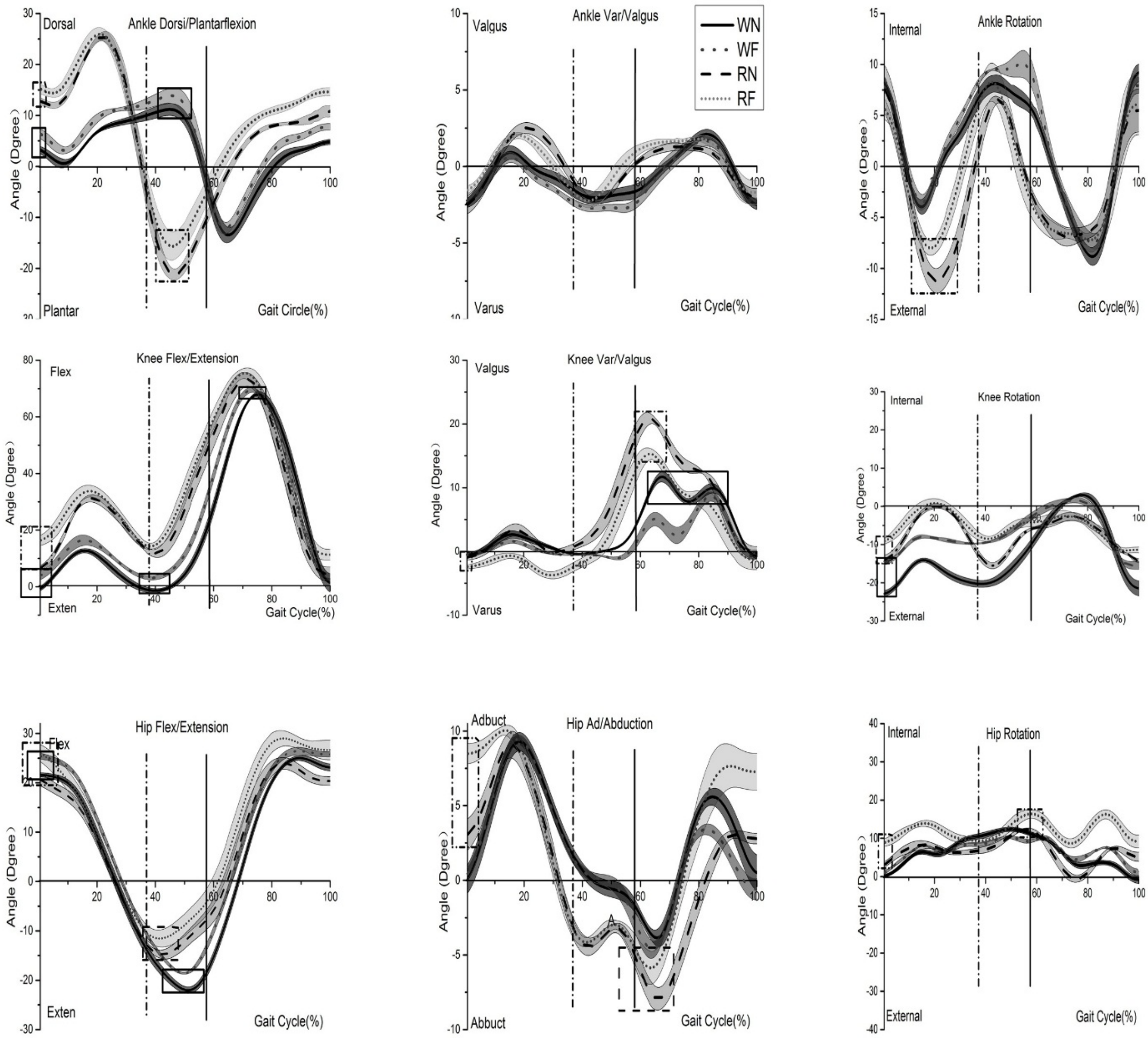

Figure 4. The angle curve of the hip, knee and ankle during one gait cycle.

Note: In the figure, the vertical dashed line represents the time when the toes are out of the ground during slow jogging while the vertical solid line represents the time when the toes are off the ground during walking. The dotted rectangular box represents significant difference between RF and RN, and the solid rectangular frame represents significant difference between WF and WN $P < 0.05$.

Fig. 4 shows the three dimensional angle of mean knee, hip and ankle joints for WN, WF, RN and RF. During walking, in the sagittal plane, the ankle dorsiflexion angle was slightly increased at initial contact during WF, as a consequence of this, the knee and hip flexion angle during WF were greater at this moment in time. The peak ankle dorsiflexion angle of WF was greater in comparison to WN. The peak flexion angle of WF was larger than that of WN. The peak knee and hip extension angle of WF were lower than WN. In the front plane, the peak knee varus angle of WF was lower than that of WN. In the transverse plane, the knee external rotation angle of RF at the initial contact was larger than that of WN. The peak knee external rotation angle of WF was lower than that of WN.

During jogging, in the sagittal plane, compared to RN, the ankle dorsiflexion angle of RF during initial contact was greater along with the knee and hip flexion angle of RF during initial contact was larger. The peak ankle plantarflexion angle of RF was larger than RN. The peak hip extension angle of RF was greater than that of RN. In the front plane, the knee valgus angle and hip abduction angle of NF at initial contact was lower than that of RN. Compared with RN, the peak knee varus angle of RF was lower. The peak hip adduction angle of RF was lower than RN. In the transverse plane, compared with RN, the peak ankle and knee external rotation angle of RF were lower. The knee external rotation angle was lower while the hip internal rotation angle of RF was larger than that of WN at initial contact. The peak hip internal rotation angle of RF was lower in comparison to RN.

3.3. GRF

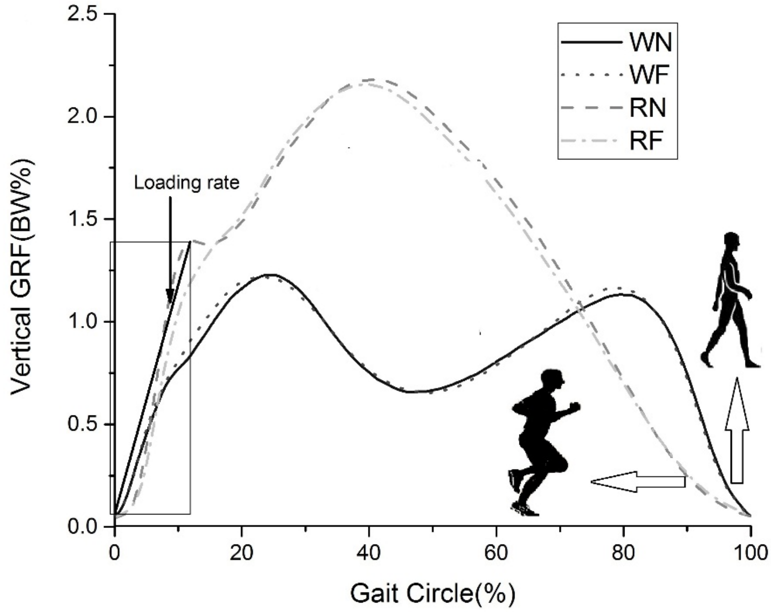

Figure 5 The GRF time curve.

Note: The black oblique line of the rectangular area represents the vertical load growth rate of RN during the initial contact phase. The vertical load rate of the GRF is the average loading rate of the contact time to the first peak time, that is, the slope value of the force - time curve of this stage.

The participants' vertical ground reaction forces (GRF) were normalized by body weight (BW). The GRF of WF and WN showed no significant difference. RN has an impact peak in the gait cycle of the stance phase, while the curve of RF is always on the rise without the peak value (the rectangular area in figure 5). In addition, the vertical load growth rate of RN in the initial contact phase was greater than that of RF ($P<0.05$).

4. Discussion

From the plantar pressure data analysis, compared to the normal insoles, the arch support functional insoles obviously reduced the peak pressure and time-pressure integral of FM and SATM and increased the contact areas of OT, FM and LMF both in jogging and walking. The force stressed on the forelimb could induce different degrees of metatarsal pain [12]. The increased loads of one or more metatarsal heads might increase the metatarsal pain during the stance phase of gait [13]. The decreased peak pressure and time-pressure integral could relieve the corresponding pain areas [14]. The arch support functional insoles redistributed the plantar pressure and was observed to effectively reduce the peak pressure of metatarsals to decrease the risk of injury under longitude stress both in jogging and walking. The suitable arch support could transfer the pressure of the heel and metatarsal to the mid-foot area [15]. In this study, wearing the arch support functional insoles obviously increased the OT, FM, and LMF regions' contact area whenever walking and jogging. However, under normal conditions, the arch areas were relatively higher than other areas, so the contact areas in this region were less.

The patients with metatarsal pain have lower pain pressure threshold, thus they needed lower peak pressure to relieve their pain [9]. During walking, the peak pressure of the whole metatarsal area was significantly lower under WF condition compared to WN. During slow jogging, the peak pressure of BT, FM, SATM, FAFM and HF under RF condition were lower than RN. However, at the OT region, the peak pressure of RF was greater than RN, this may be attributed to the fact that during slow jogging, the arch support enhances the stimulation of OT, which resulted in the OT engaging in more grip to the ground. This provided greater contact area, which finally provided an increase in peak pressure.

The time-pressure integral has important implication to injuries: the higher time-pressure integral might induce metatarsal pain and other diseases [16], the lower time-pressure integral might decrease the pain and injury risk observed [14]. With the arch support provided by the arch support functional insoles, the time-pressure integrals of BT, OT, FM and SATM obviously decreased whenever walking and jogging, this might decrease the pain and injury risk of individuals wearing the insoles. Furthermore, a previous study pointed out that the loading of FM would inevitably lead to a stress transfer to the lateral area, and promote injury risk of the other areas and further induce the metastatic metatarsal pain [13]. In this study, the peak pressure of the whole metatarsal area significantly declined during walking, the peak pressure was not transferred to the other metatarsals. During jogging, the peak pressure and the time-pressure integral of FM and SATM also decreased with FAFM changing without statistical difference.

The foot is a multi-joint system, and the intervention of the arch part might affect the movement of the other lower limb joints. Through comparing the kinematics data, differences in WN and WF, RN and RF in the lower limb joints of the hip, knee, and ankle angle captured by the Vicon motion analysis system, found no significant difference in velocity between WN and WF, or between RN and RNFI. However, the impact on the ankle, knee and hip joint angles were large, especially the angle at the initial contact and the changes in the peak angle. The data captured has demonstrated that arch support functional insoles has an influence on the kinematics of gait. Similar to a previous study, small changes were found in kinematics. In the sagittal plane, the increases in the peak ankle dorsiflexion of WF and peak ankle plantarflexion angle of RF were noted as a result of the comprehensive action of the compensatory posture adjustment made to stabilize the ankle joint [17]. The ankle dorsiflexion angle of RF and WF was significantly increased at initial contact and the knee and hip flexion angle of RF and WF were reduced at this moment, which was in accordance with previous studies that found an increase of the ankle dorsiflexion angle might induce increases of the knee or hip flexion angle [18]. With the foot orthodontic appliance, the ankle dorsiflexion increased in the initial contact phase during walking [19]. Previous articles revealed that greater knee flexion angles would lead to a greater knee flexion moment that would increase the risk of suffering [knee pain [20]. The peak hip extension angle of WF and RF was lower than that of normal conditions. The reduced hip extension during gait was helpful to reduce the force on the femoral head that could relieve the pain in the hip [21].

In the front plane, the peak knee varus angle of WF and RF were declined. One study declared that with the addition of an arch support knee varus torque was significantly increased which could promote a medial force bias during walking and jogging which might be beneficial to knee osteoarthritis patients [22]. The peak hip adduction of RF was reduced compared with RN, and according to previous studies the reduction in hip adduction may lead to a reduction in femoral internal rotation thus decreasing lateral compressive forces on the patella and subsequently improve knee pain [23]. In the transverse plane, the peak ankle external rotation angle of RF was slightly lower than RN. In this study, the peak ankle eversion angle of RF had not increased but slightly declined, but without statistically difference. This was different from findings of a previous study that suggested with a flattened arch support, the ankle eversion increased which had a limited effect to transfer the body weight to the medial longitudinal arch and even could eventually lead to different problems in the lower limb [24].

There were no significant difference of the GRF curve between the WN and WF（P<0.05), but during jogging, compared with RN, RF did not record the first impact peak. Tom et al., thought this impact peak related to the cushion of the heel contact and regarded it as the peak passive force [25].

It might be due to the arch support increasing the dorsiflexion of the ankle joint at initial contact, and decreasing the heel cushion effect, which resulted in the peak passive force declining [26]. The vertical load growth rate of RF in the initial contact phase was lower than that of RN. Furthermore, compared to the vertical, GRF was much flatter than that described by the previous articles due to the low speed and the shoes selected for this study. Many studies have suggested that GRF and vertical load growth are associated with jogging injuries, and higher loading rates might expose individuals to a greater risk for bony injuries such as knee osteoarthritis and stress fractures [27]. It is obvious that the vertical loading rate of RF and the passive impact were significantly lower, which would be beneficial to reduce the risk of lower limb injuries during jogging.

There were some limitations of this article. Firstly, as previous study indicated, it takes a long time for the foot to be fitted for the intervention [28]. This study only examined the short effect of the arch support functional insoles. Future studies should examine, the longitudinal effects of insoles and the effect of group-specific people individuals need further examination. Secondly, in the plantar pressure measurement, we put the pressure insoles on the tested insoles. These fitted the normal insoles well, but they may have been fitted correctly to the courted insoles, so the results may not replicate real conditions. Further new techniques need to be developed to investigate this issue more closely. Thirdly, the sample size of this study was small and did not involve any metatarsal pain patients. There may be opportunities in the future to investigate patients wearing these arch support insoles.

5.0 Conclusion

The results of this study have demonstrated that the arch support functional insoles could be used effectively to prevent and decrease pain and promote a more suitable weight-bearing pattern in the foot for the health of people. The arch support functional insoles applied to shoes would be beneficial in preventing the metatarsal pain and promoting medial weight-bearing. The peak pressure, contact area and time-pressure integral were significantly changed by the arch support functional insoles. The arch support functional insoles obviously reduced the peak pressure and time-pressure integral of FM and SATM and increased the contact areas of OT, FM and LMF both in jogging and walking. The kinematic data of the lower limb's hip, knee and ankle also were also different at different levels, and small changes were observed in kinematics. The vertical loading rate of RF and the passive impact were significantly lower, which would be beneficial to reduce the risk of lower limb injuries during jogging.

Conflict of interest

The authors have no conflict of interest to report

Acknowledgements

This study sponsored by National Natural Science Foundation of China (81772423), K. C. Wong Magna Fund in Ningbo University, and National Social Science Foundation of China (16BTY085).

References

[1] Cosso C, Pastorino M, Barbieri F, Aleo E, Migone S, Prono V, Cutolo M, Cimmino MA. Can MRI of the metatarsophalangeal joints differentiate mechanical from early inflammatory metatarsal pain? Annals of the Rheumatic Diseases. 2015; 74(Suppl 2): 1248-1249.

[2] Feng Y., Song Y. The Categories of AFO and Its Effect on Patients With Foot Impair: A Systemic Review. Physical Activity and Health, 2017; 1(1): 8–16.

[3] Hurn SE, Vicenzino BT, Smith MD. Correlates of foot pain severity in adults with hallux valgus: a cross-sectional study. Journal of Foot and Ankle Research. 2014; 7(1): 1-10.

[4] Chua YP, Tan W J, Yahya TS, Saw A. Prevalence of nontraumatic foot pain among urban young working women and its contributing factors. Singapore Med J. 2013; 54(11): 630-633.

[5] Besse JL. Metatarsalgia. Orthopaedics & Traumatology: Surgery & Research. 2017; 103(1, Supplement): S29-S39.

[6] Castillolópez JM, Vargasmacías A, Domínguezmaldonado G, Lafuentesotillos G, Ramosortega J, Palomotoucedo IC, Reinabueno M, Munueramartínez PV. Metatarsal pain and plantar hyperkeratosis in the forefeet of female professional flamenco dancers. Med Probl Perform Art. 2014; 29(4): 193-197.

[7] Espinosa N, Maceira E, Myerson MS. Current concept review: Metatarsalgia. Foot & Ankle International. 2008; 29(8): 871-879.

[8] Feng Y, Song Y. The Categories of AFO and Its Effect on Patients With Foot Impair: A

Systemic Review. Physical Activity and Health. 2017; 1(1), 8–16.

[9] Hodge M C, Bach T M, Carter G M. Orthotic management of plantar pressure and pain in rheumatoid arthritis. Clinical Biomechanics. 1999; 14(8): 567-575.

[10] Chen Y C, Lou S Z, Huang C Y, Su F C. Effects of foot orthoses on gait patterns of flat feet patients. Clinical biomechanics (Bristol, Avon). 2010; 25(3): 265-270.

[11]Zammit G V, Payne C B. Relationship between positive clinical outcomes of foot orthotic treatment and changes in rearfoot kinematics. Journal of the American Podiatric Medical Association. 2007; 97(3): 207-212.

[12] Brodtkorb TH, Kogler GF, Arndt A. The influence of metatarsal support height and longitudinal axis position on plantar foot loading. Clinical Biomechanics. 2008; 23(5): 640-647.

[13] García-Aznar JM, Bayod J, Rosas A, Larrainzar R, García-Bógalo R, Doblaré M, Llanos L F. Load transfer mechanism for different metatarsal geometries: a finite element study. J Biomech Eng. 2009; 131(2): 011-021.

[14] Hawke F, Burns J. Understanding the nature and mechanism of foot pain. Journal of Foot and Ankle Research. 2009; 2(1): 1-11.

[15] Sanger T D. Pathophysiology of pediatric movement disorders. Journal of child neurology. 2003; 18 Suppl 1: S9-24.

[16] Chen WP, Ju CW, Tang FT. Effects of total contact insoles on the plantar stress redistribution: a finite element analysis. Clinical Biomechanics. 2003; 18(6): S17-S24.

[17] Sousa ASP, Silva A, Tavares JMRS. Biomechanical and neurophysiological mechanisms related to postural control and efficiency of movement: a review. Somatosens Mot Res. 2012; 29(4): 131-143.

[18] Farzadi M, Nemati Z, Jalali M, Doulagh RS, Kamali M. Effects of unstable footwear on gait characteristic: A systematic review. The Foot. 2017; 31: 72-76.

[19] Nigg B, Hintzen S, Ferber R. Effect of an unstable shoe construction on lower extremity gait characteristics. Clinical Biomechanics. 2006; 21(1): 82-88.

[20] O'Connell M, Farrokhi S, Fitzgerald GK. The role of knee joint moments and knee impairments on self-reported knee pain during gait in patients with knee osteoarthritis. Clinical Biomechanics. 2016; 31: 40-46.

[21] Murray MP, Gore DR, Clarkson BH. Walking patterns of patients with unilateral hip pain due

to osteo-arthritis and avascular necrosis. JBJS. 1971; 53(2).
[22] Franz JR, Dicharry J, Riley PO, Jackson K, Wilder RP, Kerrigan DC. The influence of arch supports on knee torques relevant to knee osteoarthritis. Med Sci Sports Exerc. 2008; 40(5): 913-917.
[23] Mills K, Blanch P, Chapman AR, Mcpoil TG, Vicenzino B. Foot orthoses and gait: a systematic review and meta-analysis of literature pertaining to potential mechanisms. British Journal of Sports Medicine. 2010; 44(14): 1035.
[24] Franco AH. Pes cavus and pes planus analyses and treatment. Physical Therapy. 1987; 67(5): 688-694.
[25] Gruber AH, Edwards WB, Hamill J, Derrick TR, Boyer KA. Ground reaction forces in rearfoot and forefoot running assessed by a continuous wavelet transform. Medicine & Science in Sports & Exercise. 2015; 47(5S): 710-720.
[26] Davis IS, Rice HM, Wearing SC. Why forefoot striking in minimal shoes might positively change the course of running injuries. Journal of Sport and Health Science. 2017; 6(2): 154-161.
[27] Butler RJ, Crowell HP, Davis IM. Lower extremity stiffness: implications for performance and injury. Clinical Biomechanics. 2003; 18(6): 511-517.
[28] Kirby KA. Longitudinal arch load-sharing system of the foot. Revista Española de Podología. 2017; 28(1): e18-e26.

Appendix

Table 1 The abbreviation in this article

Full word	Abbreviation
Big toe	BT
Other toe	OT
The first metatarsal	FM
Second and third metatarsals	SATM
Fourth and fifth metatarsals	FAFM
Middle mid-foot	MMF
Lateral mid-foot	LMF
Hind-foot	HF
Jogging with the ‘arch support functional insoles’	RF
Walking with the ‘arch support functional insoles’	WF
Walking with the normal insoles	WN
Jogging with the normal insoles	RN
Ground reaction force	GRF